

The material 10 to be applied is placed into the storage container 9. In the storage container 9, the material, e.g., in the form of a suspension or paste, is stirred with a fan-type stirrer 11 at 50 to 3000 rotations/minute. The storage container 9 is attached to a three-axis CNC controlled positioning unit. A pressure of 0.07 to 0.80 bar can be adjusted via the pressure balancing line 12 and the valve 13.

The carrier to be processed, meaning the element to be sprayed, for example, a sensor ceramic carrier, is inserted into a rotatable holder that is also CNC controlled and permits rotation around the longitudinal axis of the ceramic carrier 2. FIG. 2 shows the inside bore of a sensor ceramic carrier 2. With CNC control, the tubes 3 and 5 are driven or moved vertically into the inside bore of the carrier 2. The valves 8 and 14 for the air and material feed tubes 3 and 5 are opened as soon as the discharge openings 4 and 6 of the tubes are inside the inside bore of the carrier 2. The air flows out of the opening 4 with a pressure of 0.01 to 7 bar. The material 10 to be applied flows out of the discharge opening 6 of tube 5 and is sprayed to the side, i.e., literally, owing to the air flow that affects the discharging material 10. The conductive lead line is applied to the inner surface of the carrier while the tubes are inserted into the inside bore of the ceramic carrier. The CNC control subsequently turns the ceramic 2 once around the longitudinal axis, thereby creating a ring of applied material. The tubes 3 and 5 are then pulled back by a defined distance and the ceramic carrier 2 is rotated another time around the longitudinal axis. A ring of applied material is again created on the inner surface of the carrier 2 in the inside bore. The spraying time for each spraying surface can be between 0.001 and 99 s. The valves for the air and material feed are then closed, and the tubes 3 and 5 are pulled out of the bore of the ceramic carrier.

The inventive device permits a precise application of the desired material in any optional contour, even on surfaces that are traditionally hard to process.

#### Exemplary Embodiment 1

The application of an inside electrode of a sensor ceramics for gas sensors 1.

A cermet suspension containing precious metals, such as described in DE 4100107, is filled into a storage container with plastic liner. The suspension is stirred inside the storage container with a wing-type stirrer at approximately 500 RPM. The storage container with spray head (tubes) is attached to a three-axis CNC controlled positioning unit (compare FIG. 2).

In order to apply the inside electrode to the carrier, the presintered sensor element or carrier is fastened in a rotatable holder that is also CNC controlled and permits a rotation around the longitudinal axis of the ceramic carrier. The feed tubes 3 and 5 are inserted vertically into the inside bore of the ceramic carrier. The valves for the air and material feed are opened as soon as the discharge openings of the tubes enter the bore of the carrier. The material is squeezed out of the tube (inside diameter=1.2 mm) with a pressure of approximately 0.2 bar. The air has a pressure of 1 bar (tube: inside diameter=0.9 mm; closed at the end, with side discharge opening of 0.3 mm inside diameter). Accordingly, the material is sprayed to the side, i.e., laterally relative to the longitudinal axis of the bore. The spraying head formed by tubes 3 and 5 is inserted approximately 30 mm into the inside (interior) bore of the ceramic carrier where the lead line is to be applied to the carrier's inner surface. The ceramic carrier 2 is then rotated within 1 second around the longitudinal axis by 360°. Subsequently, the spraying head is pulled back by about 1 mm and the ceramic carrier is rotated a second time by 360°. Two rings of cermet

are formed in this way in the inside bore of the ceramic carrier, which rings form the inside electrode. Following this, the respective valves for the air and material supplies are closed, and the tubes of the spraying head pulled out of the ceramic carrier. The ceramic carrier is then dried and subsequently sintered.

#### Exemplary Embodiment 2

Application of an inside electrode for a sensor ceramic carrier for gas sensors II.

Creating the suspension containing precious metals (electrode paste):

Composition:

- 40% in weight platinum powder
- 5% in weight  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> powder in 25% in weight terpinol
- 24% in weight ethanol
- 3% in weight alkyl cellulose and
- 3% in weight additive.

The mixture is then homogenized for 2 h in a suitable device (e.g., planetary mill).

The suspension with precious metals is placed into a storage container 9 with a plastic liner. Inside the storage container, the suspension is stirred at approximately 500 RPM with a wing-type stirrer. The storage container with spray head (tubes) is fastened to a three-axis CNC controlled positioning unit (see FIG. 2).

The outside electrode is then applied and the ceramics subsequently sintered.

In order to apply the inside electrode, the sensor element, which is also CNC-controlled and can rotate, is inserted into a holder that permits a rotation around a longitudinal axis of the ceramic carrier. The material and air tubes are inserted vertically into the inside bore of the ceramic carrier or sensor element. The valves for the air and material supply are opened as soon as the discharge opening for the tubes enter the inside bore. The material is squeezed out of the tube (inside diameter=0.8 mm) with a pressure of approximately 0.5 bar. The air has a pressure of 2.5 bar (tube: inside diameter 0.6 mm; closed at the end, with a side discharge opening of 0.2 mm inside diameter). Accordingly, the material is sprayed to the side. The tube is inserted approximately 20 mm into the inside bore of the ceramic carrier, where the conductive lead line is to be applied. The ceramic carrier is then turned or rotated around the longitudinal axis by 360° within one second. Subsequently, the tube is pulled back approximately 0.8 mm and the ceramic carrier is turned or rotated a second time by 360°. Two rings of electrode paste are produced in this manner on the inner carrier surface within the inside bore of the ceramic carrier. Following this, the valves for the air and material supplies are closed and the tubes pulled out of the bore of the ceramic carrier. The ceramic carrier is dried, and the inside electrode is subsequently baked in a reducing atmosphere (5% H<sub>2</sub> in N<sub>2</sub>).

According to the invention, it is also possible to provide for a feeding of the material or air through more than one tube respectively. In such a case, a device for carrying out the inventive process has a corresponding multiple number of feed tubes, for example three or four.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

What is claimed is:

1. A process of applying an electrode to a carrier of ceramic material, said process comprising the steps of:
  - providing a tube-shaped carrier of ceramic material;

supplying electrode material to a spray tube which produces a laterally directed spray of the electrode material;

advancing the spray tube into the hollow space of the tube-shaped carrier along a longitudinal axis of the tube-shaped ceramic carrier while non-rotating and while spraying the electrode material to apply a lead-in conductive track of the electrode material on the inner side wall of the tube-shaped ceramic carrier; and

subsequently, rotating the tube-shaped ceramic carrier about its longitudinal axis relative to the spray-tube while continuing the spraying to produce a first ring-shaped electrode on the inner side wall of the tube-shaped ceramic carrier and in contact with the conductive track.

2. A process according to claim 1, wherein the step of spraying includes separately supplying the electrode material and air used for the spraying to the spray tube, and subsequently atomizing the electrode material with the air.

3. A process according to claim 2, wherein the air is supplied through a first tube under a pressure greater than >0.01 bar.

4. A process according to claim 3, wherein the electrode material is supplied through a second tube under lower pressure.

5. A process according to claim 4, wherein the step of atomizing includes disposing discharge openings for the tubes at an acute angle or at a right angle to each other.

6. A process according to claim 2, wherein a metered feeding of at least one of the air and the electrode material takes place.

7. A process according to claim 1, wherein the carrier is composed of one of sintered-on or sintered ceramic material or is coated with sintered ceramic material.

8. A process according to claim 1, wherein the material is supplied in the form of a paste or suspension.

9. A process according to claim 1, wherein the electrode material is electrically conductive.

10. A process according to claim 9, wherein the electrode material is cermet.

11. A process according to claim 1, wherein the electrode material contains or is composed of perovskite, or a precious metal, from the group of platinum, palladium and rhodium.

12. A process according to claim 1, wherein the electrode is applied to a carrier of an exhaust-gas sensor. subsequently,

rotating the tube-shaped ceramic carrier about its rotational axis, relative to the spray-tube while continuing the spraying to produce a ring-shaped electrode on the inner side wall of the tube-shaped ceramic carrier.

13. A process according to claim 1, wherein the step of rotating comprises rotating the tube-shaped carrier once by 360°.

14. A process according to claim 1, wherein the tube-shaped carrier is vertically oriented, and said step of advancing includes advancing the spray tube vertically into the hollow space of the tube-shaped carrier.

15. A process of applying an electrode to a carrier of ceramic material, said process comprising the steps of:

providing a tube-shaped carrier of ceramic material;

supplying electrode material to a spray tube which produces a laterally directed spray of the electrode material;

advancing the spray tube into the hollow space of the tube-shaped carrier along a longitudinal axis of the tube-shaped ceramic carrier while non-rotating and while spraying the electrode material to apply a lead-in conductive track of the electrode material on the inner side wall of the tube-shaped ceramic carrier;

subsequently, rotating the tube-shaped ceramic carrier about its longitudinal axis relative to the spray-tube while continuing the spraying to produce a first ring-shaped electrode on the inner side wall of the tube-shaped ceramic carrier; and,

following the step of rotating, stopping the rotation and linearly withdrawing the spray tube for a given distance and then again rotating the tube-shaped ceramic carrier about its rotation axis relative to the spray-tube to form a second ring-shaped electrode, that is linearly spaced from the first ring shaped electrode, on the inner side wall of the tube shaped ceramic carrier; and thereafter discontinuing the spraying and withdrawing the spray tube from the hollow interior space of the tube-shaped ceramic carrier.

16. A process according to claim 15, wherein the steps of rotating, in each case, comprise rotating the tube-shaped carrier once by 360°.

\* \* \* \* \*

09913901-073101

17. A method for manufacturing an O<sub>2</sub> sensor element having a cup-shaped solid electrolyte member having an inside space with an opening, an outside electrode provided on an outside surface of the solid electrolyte member, and an inside electrode provided on an inside surface of the solid electrolyte member within the inside space, the method comprising steps of:

preparing a nozzle having a paste discharge hole at a front end thereof, the paste discharge hole being for discharging conductive paste for forming the inside electrode;

inserting the front end of the nozzle into the inside space of the solid electrolyte member;

relatively rotating the paste discharge hole of the nozzle with respect to the solid electrolyte member along the inside surface of the solid electrolyte member while discharging the paste from the paste discharge hole onto the inside surface of the solid electrolyte member;

removing the nozzle from the solid electrolyte member; and  
baking the solid electrolyte member.

18. The method of claim 17, wherein in the step of relatively rotating the paste discharge hole with respect to the solid electrolyte member, one of the paste discharge hole and the solid electrolyte member rotates.

09918901.073101

18

19. A method for manufacturing an O<sub>2</sub> sensor element having a cup-shaped solid electrolyte member having an inside space with an opening, and an inside electrode provided on an inside surface of the solid electrolyte member within the inside space, the method comprising steps of:

5 preparing a nozzle having a paste discharge hole at a front end thereof, the paste discharge hole being for discharging conductive paste for forming the inside electrode;

inserting the front end of the nozzle into the inside space of the solid electrolyte member;

10 relatively rotating the paste discharge hole of the nozzle with respect to the solid electrolyte member along the inside surface of the solid electrolyte member while discharging the paste from the paste discharge hole onto the inside surface of the solid electrolyte member; and

removing the nozzle from the solid electrolyte member.

15

20. The method of claim 19, wherein in the step of relatively rotating the paste discharge hole with respect to the solid electrolyte member, one of the paste discharge hole and the solid electrolyte member rotates.

20

25

05918901-073101